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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 24 June 2003 with an application for Letters Patent number 526666 made by Propeller Jet Limited..

I further certify that the Provisional Specification has since been post-dated to 14 July 2003 under Section 12(3) of the Patents Act 1953.

Dated 2 August 2004.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Neville Harris

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Commissioner of Patents, Trade Marks and Designs

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526666

POST-DATED UNDER SECT. 12(3)
TO 14-7-2003

Patents Form No. 4

Patents Act 1953

PROVISIONAL SPECIFICATION

IMPELLER DRIVE FOR A JET PROPULSION UNIT

We, PROPELLER JET LIMITED, a New Zealand company of Domeburn Station, R.D. 7, Gore, Southland, New Zealand, do hereby declare this invention to be described in the following statement:

2? JUN 2003
RECEIVED

Title: IMPELLER DRIVE FOR A JET PROPULSION UNIT

Field of the Invention

This invention generally relates to water jet propulsion apparatus for propelling boats and other watercraft, however it is also applicable to stationary pumps and electric generating plants.

Background of the Invention

Water jet propulsion apparatus operate by utilizing the reaction forces resulting from propelling a mass in one direction thus creating an equal and opposite force in the other direction.

A high-pressure jet produces its thrust substantially in the nozzle section at the rear of the device. The impellers are fine in pitch so that they are able to produce a pressure head, which in turn creates a large change in velocity as the water is forced through a rapidly reducing outlet. The water speed forward of the nozzle section in a water jet operating above the water line, is not the same as the water speed of the boat or craft. The water speed in the intake and impeller section is greatly below boat speed, and so the change in velocity is calculated from the net change in velocity from the intake to the outlet of the nozzle, the greater change taking place in the latter.

Prior Art

A high pressure jet propulsion system is disclosed in U.S. Patent 3044260 (Hamilton). High-pressure jets are characterised by impellers that have a low advance coefficient. A greatly reducing nozzle cross-sectional area results in a very large change in water velocity, and thus thrust is produced. At low impeller tip speeds, a combination of the low nozzle pressure and the low advance coefficient impellers, means that high-pressure jets are not very efficient.

A water jet propulsion system has a markedly reduced water speed forward of the impeller. Water diffuses into an intake section in front of the impeller, and as it does so, it slows down. This slowing down of the water as it passes through the body of the pump reduces losses through friction. The stators (water straightening vanes, placed downstream from the impellers) also represent a potential for frictional losses if the water speed through them is raised too high. The use of low advance coefficient

impellers keeps the velocity low, but enables very high pressure to be produced in the nozzle section. This locks a high-pressure jet system into having a configuration where a relatively low mass of water is accelerated to very high velocities in a nozzle section located downstream from all of these structures.

Other forms of high pressure pumps have been described in U.S. Patent 3,269,111 (Brill) and 3,561,392 (Baez).

A variety of adjustable discharge nozzles have been described for instance in US Patent 5,658,176, (Jordan) which teaches a nozzle pressure control device designed to optimise the pressure in a high-pressure pump. Jordan does not define the conditions necessary for optimal efficiency in a low-pressure pump, it refers to the "pumping means forcibly delivers the water through the nozzle thereby propelling the craft..."(Column 1 lines 14-17). This is clearly referring to the thrust being generated in the nozzle section. The inclusion of a stator section also precludes this device from being a low-pressure pump.

U.S. Patent 6,293,836 (Blanchard) describes an adjustable nozzle for a high-pressure pump. At column 1 lines 27-29 there is a reference to pressure being developed in the nozzle, where it is stated: "A smaller opening is also desirable for low-speed manoeuvring, as it would result in higher velocity of the exiting water flow at low engine rpm."

All of these propulsion systems referred to above have attributes specific to the characteristic relating to their designs. It is known that high pressure jet propulsion systems are particularly effective in shallow water operation. The shortcomings of a jet propulsion system however, relate generally to its slow to mid speed operation. A water jet requires high pressure in order to create a velocity change in the nozzle section sufficient to produce usable thrust. To achieve this, the known systems employ a fine pitched, pressure-inducing impeller or impellers, followed by one or more stator sections, and then a reducing nozzle. The fine pitched impellers range from about 11-20 degrees, and thus have a reduced advance coefficient (ratio of boat speed to impeller tip speed). At slow impeller revolutions, they develop relatively low thrust. For fishermen who require both good boat speed to reach their destinations, but also slow speed control at low engine revolutions when working nets and pots etc. the jet is limited, as it expels a relatively low mass of water at low plume velocity. In rough sea

to a propeller operating near the surface of the water. Previously, the Davies et al. low pressure pumps have been defined as requiring an outlet cross-sectional area ratio of about 0.55 to less than the swept area of the front impeller. What this is saying, is that the outlet area starts at about half the area of the front impeller, and operates with nozzle size that is equal to, and larger than that.

The ratio of the exhaust outlet is linked directly to the change in velocity across the impellers, and starts with a very large exhaust outlet which is about half the front impeller diameter (0.55) at very low impeller rotational speeds, when the craft is on the plane, and gets progressively smaller (not larger) as the rotational energy from the impellers is imparted to the water, and a greater change in velocity starts to take place.

Operating the pump with exhaust outlet sizes much less than the area suggested by a ratio of 0.55:1, particularly at high rotational velocities, does not result in a drop in efficiency. At higher rotational speeds it is imperative to reduce the exhaust outlet area in order to prevent ventilation from reducing the pump's normal operation. This smaller opening at the outlet is not changing the pump into a high-pressure pump; it is simply altering the outlet to accommodate the change in velocity that takes place as the water accelerates over the impellers, so that ventilation will not occur.

At each range of impeller tip speeds there is an optimum exhaust outlet size, that creates a balance between two opposing variables, that is ventilation, and too much backpressure. An adjusting anti-ventilation device can be placed in the exhaust outlet to accommodate the different priming requirements across a wide range of impeller revolutions per minute. This device is not always necessary, as the exhaust outlet size may be fixed at a target setting, however there are some situations where its use will aid the jet's operation. At slow internal pump velocities, the exhaust outlet opening would be at its largest, and would be characterised by a very low plume velocity. If the jet outlet was to remain under the water during operation, then the outlet can be larger again. As the water velocity increases through the pump, the exhaust outlet must reduce in area, to control ventilation, and enable the craft to be driven onto the plane, and up to very high speeds.

Object of the Invention

It is an object of this invention to provide an improved low pressure high mass pump which will overcome the effects of ventilation, and high backpressures. Such a

system will also reduce the damage that high velocity plumes ejected from traditional high-pressure jets create in fragile environments. It is also safer for the user, as the expelled water is at a much lower velocity, and more diffuse or less concentrated, than traditional water jets.

By providing a propulsion system that can produce high thrusts at low impeller revolutions, the consumer will have a viable alternative to traditional propeller systems but in a jet package. At high speeds, control over ventilation enables the jet to remain primed, and thus efficient. The use of a low back pressure, anti ventilation control device placed in the outlet, or in between the two impellers, ensures that maximum thrust is produced across a wide range of operating conditions.

<u>Summary of the Invention</u>

In one form the jet propulsion unit comprises an intake housing, a pump housing, and an outlet housing,

a pair of counter-rotating spaced apart impellers constructed with opposite pitches mounted on counter rotating concentric shafts within the pump housing,

wherein the upstream impeller has a diameter which is less than the inner diameter of the wall of the pump housing to leave a clearance between the outer tips of the impeller blades and the inner wall of the pump housing, and

wherein the downstream impeller has a diameter that will leave a minimal clearance between the outer tips of the blades of the impeller and the inner wall of the pump housing.

Preferably the intake housing is bulged outwardly upstream of the upstream impeller.

Preferably the impellers are mounted on concentric counter rotating shafts.

Preferably the upstream impeller has a smaller diameter that the diameter of the downstream impeller.

Preferably a wear ring is positioned on the interior of the wall of the housing to register with the tips of the blades of the downstream impeller.

Preferably means are provided to vary the cross sectional diameter of the outlet.

Preferably the cross sectional area of the outlet can be varied between about .55 and 0 as a ratio of the area of the downstream impeller blades.

Preferably the means are provided to vary the cross sectional diameter of the outlet includes a conical piston which is oriented in the outlet to have its longitudinal dimension concentric with the shaft which drives the impellers, said piston being adapted to move forwardly and rearwardly on the shaft to vary the cross sectional diameter of the outlet.

Preferably the piston is spring loaded in a manner that when the velocity of water flowing over the piston falls, the piston will be forced back into the largest diameter of the outlet.

Brief Description of the Drawings

FIG 1 is a side elevation sectional view of a low pressure/ high mass water jet pump according to this invention.

FIG 2 is a side elevation view of a modification of the pump housing and outlet illustrating a low pressure self adjusting anti ventilation device positioned downstream from the downstream impeller.

Detailed Description of the Preferred Embodiments

Fig 1 depicts a low pressure/high water mass water jet pump that has an intake housing 1, a pump housing 13, and an outlet housing 23. As illustrated in the drawing the intake 1 is bulged at 1a just forward of the upstream impeller 2a which will tend to reduce the velocity of the water in the intake and add volume.

A pair of counter-rotating impellers 2a and 2b constructed with opposite pitches are supported on counter rotating concentric shafts 3 and 3a which enter the intake housing 1 through an extension 4 formed as part of the intake housing. The shafts are supported by bearings 5 within a shaft support 25 and are protected from water damage by seals 17. The driving means and the method for creating counter-rotation on the shafts is not shown. Various engine combinations, gearings and gearboxes can be used to give the desired opposite rotation on the shafts, and is well known in the

art. The means of achieving counter-rotation may also be achieved by driving the impellers by means of a gearbox placed behind the downstream impeller, between the two impellers, in the intake section, or any combination between these positions.

The impellers 2a and 2b are locked onto the driven shafts by keys 21, and held in place by locking nuts 20. The inner shaft is supported at the rear of the unit inside the outlet housing 23 by a coned structure 18 which is held in place by thin hydrodynamic vanes 15. These vanes should be little in number and streamlined, so that they do not unnecessarily induce drag or friction in the pump housing section 13 which in this embodiment is depicted as tubular, and parallel.

The impeller 2a is an upstream or swirl inducing device that has a large clearance 2c between the tips of the impeller and the inner wall 7 of the housing. The downstream impeller 2b has a tight tolerance between the tips of the blades of the impeller and the inner wall of the pump in order that the impeller will remain fully primed.

The pressure of water in the intake will be lower than the pressure between the impellers 2a and 2b and consequently the large gap between the tips of the blades of the impeller 2a and the inner wall of the pump will tend to equalize the pressure between the two impellers and the intake. As the speed of the boat increases, this will increase the pressure in the intake and consequently the pressure between the impellers will progressively increase with the speed of the boat until the boat reaches an optimum speed where the pressure will not longer increase.

Once rotational energy is applied to the shafts and the impellers start to turn, they produce a drop in pressure in the intake housing, which primes with water. The arrow 9 depicts the direction of water flow.

The purpose of the upstream impeller 2a is to impart a degree of spin or swirl to the water which is sufficient to neutralize the spin or swirl imparted to the water by the downstream impeller 2b. It will be noted that the outer diameter of the upstream impeller 2a is considerably less than the outer diameter of the downstream impeller 2b which will also minimize pressure build up between the upstream and downstream impellers. Preferably a wear ring or the like (not shown in the drawings) is located inside the pump housing around the tips of the blades of the downstream impeller 2b.

It is also envisaged that another method to impart the degree of swirl or spin to the water could be effected by replacing the impeller 2a by open bladed propeller like device. The open nature of the blades would ensure that pressure would not build up between the two impellers and the blades could extend to the walls of the pump housing. The open nature of the blades would allow the downstream impeller 2b to exert an influence on the water and start to straighten the swirl in the water before it exits the propeller like impeller.

The counter-rotation of the downstream impeller 2b removes the rotational energy imparted to the water by the upstream impeller 2a, resulting in linear flow in the exhaust outlet 6. This removes the need for straightening vanes (stators) commonly found in other jet propulsion units.

As the water in the intake passes through the upstream impeller, it is spun and driven outwards towards the inner walls of the pump housing. By the time it progresses to the rear of the upstream impeller 7 and is now annulus in appearance and spiraling rearwards along the pump housing walls towards the downstream impeller. The downstream impeller is designed to straighten the water, by removing the radial energy. By the time the water exits the rear of the downstream impeller 8, it is axial in flow, and annulus in shape. The vortex that has been created by spinning and acceleration of the water must now be plugged as illustrated at 22, or alternatively, the walls of the outlet housing 23 must be reduced to prevent air entering the pump. It is desirable not to slow the exiting water at this juncture, as a drop in thrust will result.

In this embodiment, a fixed outlet 6 is used, that has been designed with a smooth coned plug 18 that increases in diameter the closer it is to the outlet 23. The desired cross-sectional area of the outlet 6 will vary according to the rotational velocities of the water over the impellers, and will fall between about 0.55 and 0 as a ratio of the area of the upstream impeller blades and the outlet. The operator is able to alter the diameter of the cone 22, to give maximum thrust at the desired outlet water velocity. The cross sectional area of the outlet 23 is such that it will prevent or substantially prevent air from re-entering the pump and thus cause ventilation. In addition the cross sectional area of the outlet will be such that a minimum of back pressure will be maintained against the downstream impeller while maintaining the impedance of the water as it exits the outlet as low as possible.

This invention accepts that linear flow on the exiting water is necessary, however it is the control of ventilation, in conjunction with low back pressures that enables the pump to operate efficiently.

Fig 2 is a sectional representation of a water jet pump housing 13 (intake section 1 not shown) and a reducing outlet housing 16. In this example an adjusting ventilation control device 11 is employed. It is located on the rear of the inner shaft support structure 18.

Ventilation and low backpressures are controlled automatically, using the flow of the water over a piston 11. The tension of a spring 12 holds the piston against the flow of water, to position the piston 11 along a shaft 10, and thus alter the outlet cross-sectional area to accommodate the different water velocities produced by the pump and maintain an outlet ratio necessary for the prevention of ventilation across a much wider range of outlet water velocities.

The piston 11 is coned in shape and is designed to fit against the rear of the inner shaft support 18. The inner shaft support structure 18, is held in place by thin vanes 15, designed to allow water to pass over them with little turbulence.

The increasing water velocity will drive the piston 11 backwards into a reducing outer diameter 16. This will prevent air from entering and depriming the pump, by reducing the cross-sectional area of the outlet at greater water velocities. As the water velocities fall with lower shaft rpm, the piston will be forced back into the largest diameter section of the outlet, thus increasing the cross-sectional area, and maintaining the state of low back-pressure. The tension on the spring 12 can be adjusted by altering the position of the nut and retainer 9 along a threaded shaft 10.

Other means of achieving the same ends are not excluded from this description. For example, mechanical, electrical, pneumatic or hydraulic devices could be employed to position the piston along the shaft and these may be either automatic or manually controlled. The walls of the outlet housing may also be adjusted to control ventilation.

Methods for keeping particles or marine growth away from the moving parts may also be employed. These may include flexible covers, or sealed compartments as will be known in the art.

It is understood that those skilled in the art could make various changes within the structures present inside the pump to carry *out* a similar function. Therefore it is the intention of this invention to teach the essential elements necessary to control ventilation while maintaining low back-pressures in a high mass jet pump operating at or above the water line. The particular drawings presented are not intended to be restrictive, or limiting, and it is the intention that the invention will include all configurations falling within the scope of the claims.

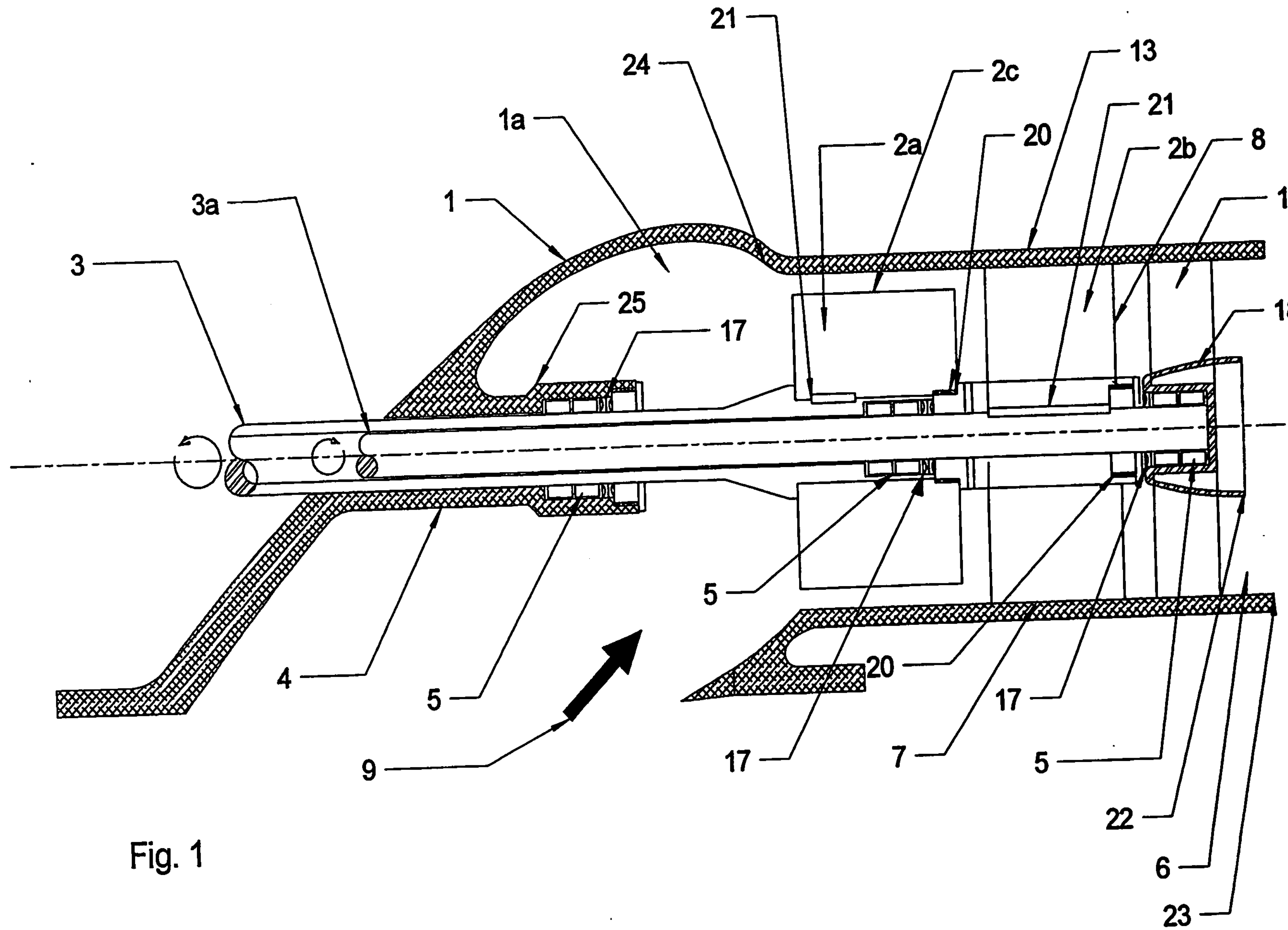

Fig. 1

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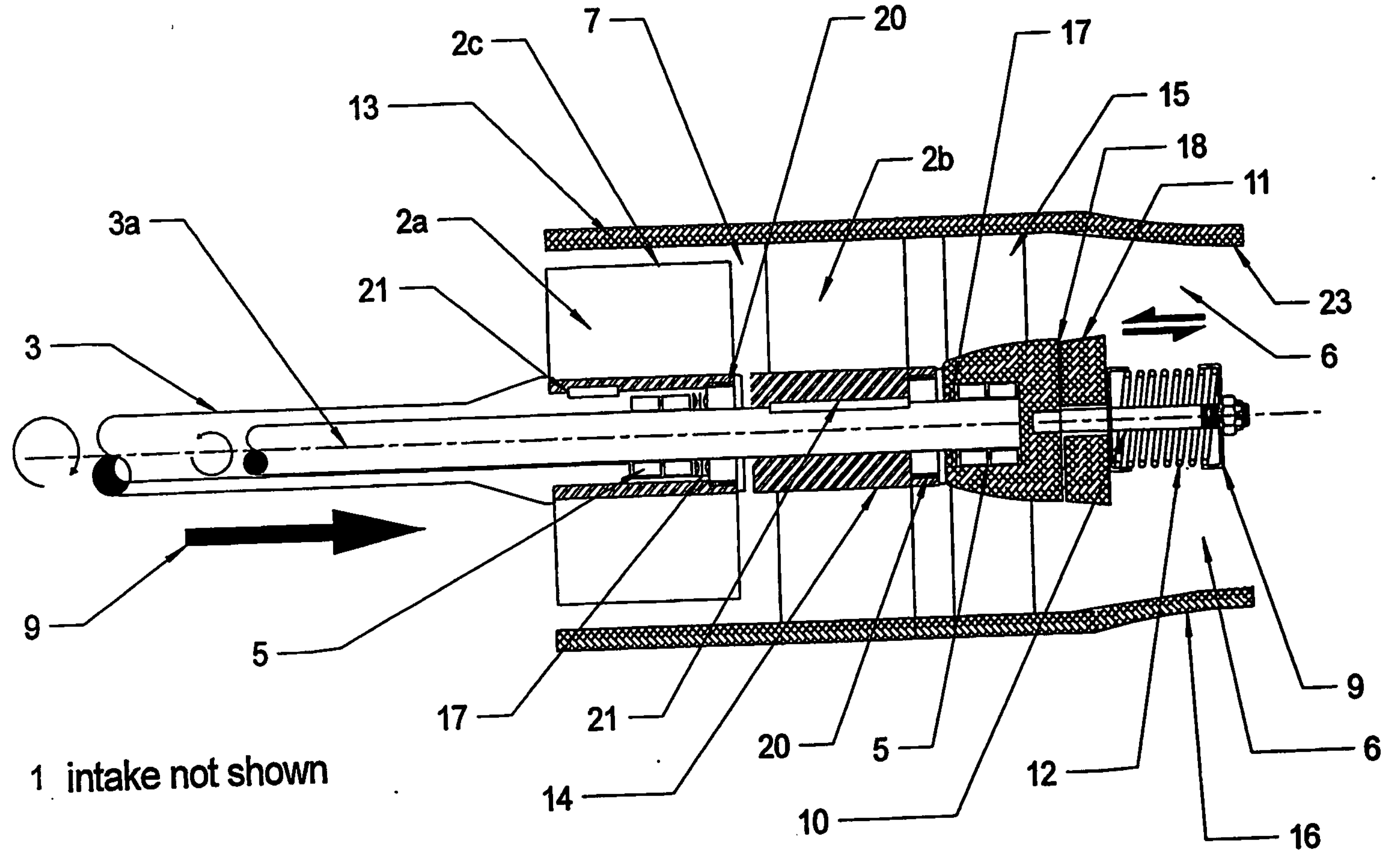

1 intake not shown

Fig. 2